Enhancing Depression Detection Accuracy in Northwest Nigerian Adults Using Ensemble Learning Technique

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Abstract — Millions of individuals all over the world suffer from depression, a serious and common mental illness. In Northwest Nigeria, depression is still not well recognized because of stigma, the use of multiple languages, including English, Hausa, and Fulfulde, and a lack of mental health resources for thorough detection. In order to increase accuracy and equality across language groups, this study suggests an ensemble-based detection architecture that incorporates complementary classifiers trained on clinical screening datasets. Researchers have used artificial intelligence (AI) to automatically detect depression symptoms. Majority of healthcare researchers and management use series of machine learning techniques to improve disease detection, diagnosis, and prediction in order to aid in the decision-making. This study investigates how well machine learning ensemble techniques can improve the precision of depression detection in northwest Nigeria. Four individual base machine learning algorithms such as Randon Forest, Decision Tree, Support Vector Machine and K-Nearest Neighbors will be used as a pipeline combination of the classifiers to form Stack Ensemble technique that will be trained on clinical screened dataset from Primary Health Care Centers to enhance depression detection. The entire model will be evaluated using the appropriate machine learning metrics such as accuracy, precision, F1-score, recall and ROC-AUC respectively.

Keywords — Stack Ensemble, Machine learning, Depression, Support Vector Machine, Naïve Bayes.

I. INTRODUCTION

Masses around the globe suffer greatly from depression, a common mental health illness that impacts people of all ages and backgrounds [28], [24]. It is a prevalent mental health condition with significant social and economic consequences; it has been investigated by some few researchers how grave it was to community health issue. Depression is a temperament disorder characterized by loss of interest, persistent sadness, weariness, and impaired functioning. Universally, it affects over 280 million people according to the World Health Organization [28].

Due to social ignorance, poor health infrastructure, cultural stigmatization and restricted access to qualified specialists, depression in Northwest Nigeria is still mostly underdiagnosed and underreported. In order to facilitate prompt intervention, lessen the burden of untreated cases, and enhance the mental health of impacted communities, early detection is essential. It is critical to address depression with efficient detection and interventional techniques because the disorder affects not only the afflicted individuals but also their relatives, communities, and health care systems [26].

In recent, there have been a continuous increase in depressions in Northwestern Nigeria, due to persistent threats from bandits which leads to kidnapping, insurgency and common dissension that causes suffering and Internally Displaced Persons (IDPs). Mass displacement has resulted from decades of violent conflict and banditry in the Northwest. This rising issue of unrest has prompted intense shocks and depression among individuals in the region.

In these regards, Nigeria is a point of view with specific interest in Northwestern part where depression incidence and awareness is still confined in those zones, due to quoted influences like social ignorance, lack of quick mental health diagnosis and importantly deficiency on mental health instructions [24]. In Northwestern Nigeria, depression identification is still insufficiently detected, despite increased awareness of mental health concerns. There are other numerous elements that contribute to this issue such as depressive symptoms which are frequently stated differently in Hausa, Fulfulde, and English, which makes it difficult for detection systems that use a single language model to work.

II. RELATED WORK

Depression is a temperament condition categorized as loss of interest, persistent sadness, weariness, and impaired functioning. Universally, it affects over 280 million people, according to the World Health Organization [28]. People who

are struggling with depression might treasure using social media platforms to communicate with others can to have self-relive on their lives [13], [5]. In Northwest Nigeria, cultural stigma, limited mental health professionals, and poor awareness contribute to under-diagnosis. Depression has social, economic, and health consequences, including reduced productivity, poor academic performance, and increased risk of suicide. Due to the prevalent occurrence of depression as well as the effects it has on both individuals and society, it is significantly important that depression is quickly detected [1],[9].

Social networking is speedily becoming a healthcare valuation tool for predicting variety of medical issues that people are facing today, the depressed people frequently utilize and interact with friends, family, and groups on social platform [21]. From all perceptions, there isn't any wide range of assessment of the prevalence of depression in Northwestern Nigeria [24]. People of all ages and backgrounds are susceptible to depression, the common mental health condition. We aim to enhance a machine learning ensemble technique for accurate depression detection in Northwest Nigeria. Recent developments in machine learning have shown how automated systems can help predict mental health issues, especially when text-based data from clinical notes, social media, and community health records is analyzed. However, the accuracy of single individual model approaches is frequently limited by issues including cultural manifestations of distress, class imbalance in accessible datasets, and multilingual communication such as English, Hausa and Fulfulde [19], [14].

Due to the dominant occurrence of depression as well as the effects it has on both individuals and society, it is significantly important that depression is quickly detected [10]. The health practitioners have been using several machine learning algorithms to reveal depression in different datasets, but the key component of these methods is based on the idea that different models can perform better when combined than when used individually. [18], [8] employed deep learning and discovered that recurrent neural networks (RNNs) worked effectively. However, they made sure that ensemble approaches that combined SVM and other models may enhance outcomes even more. [5] examined text mining for health applications in Nigeria, where they identify linguistic variety and data scarcity as significant obstacles. [4], [25] emphasized the need for culturally sensitive Natural Language Process (NLP) resources for Hausa and Fulfulde in mental health detection. Consequently, these studies have indicated that depression detection research is growing globally but limited efforts exist in Northern Nigeria especially in the Northwest region. when depression is identified early and treated with the right medicine, victims can be cured. Emotional and physical therapies can also be utilized to treat and alleviate depression [27], [23].

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III. STUDY AREA

Nigeria is composed of about 400 ethnic groups and 525 languages. The Northwest is one of the six geopolitical zones of Nigeria representing both a geographic and political region of the country's northwest. It comprises of seven states out of the 36 states of Nigeria, and these states are Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. The six states were not entirely carved out based on geographic location, but rather states with similar ethnic groups and common political history were classified in the same zones. This region is the largest in the country by both population and landmass. The economy is largely dependent on agriculture, which includes cattle and crops like sorghum and millet. The majority of the population is made up of the Fulani and Hausa ethnic groups, with Islam as their predominate religion in the area.

The percentage of the Northwest of Nigeria is 19.4% while the rest states are of 80.6% which is represented in figure 1 respectively.

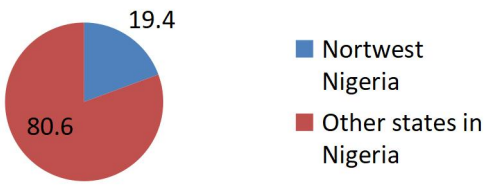

Fig 1: Pie chart percentage of Northwest states and other states in Nigeria

The percentage in population according to Nigeria Census 2006, the Northwestern part of Nigeria has an approximately 23.5% of the total population in Nigeria. Figure 2 below depicted it in a bar chart.

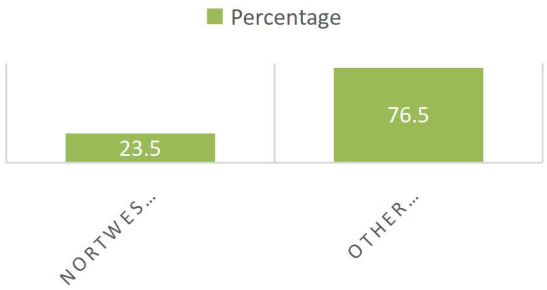

Fig 2: Bar chart percentage of Northwest population and other states in Nigeria

Today, the Northwest part of Nigeria has become a straight line of entry by foreigners from Niger republic and other neighboring countries. The population kept increasing gradually and different tribes been welcomed with different attitudes and behaviours [17]. In this regards a well-trained medical practitioner need to focus on the linguistic process in treating depression patient. because most of the depression patients may find it very difficult to express themselves in spoken English. For this reason, an ensemble model was developed to enhance the prediction of depression in Northwest part of Nigeria.

The Stack ensemble model accept input phrase from three different dialects that is Hausa Fulfulde and English that was extracted from patient during examining and consultation then entered into the model by the practitioner for prompt results. This enables the medical personals to quickly identify the patient depression stage in order to enhance in the necessary medications.

IV. METHODOLOGY

The crucial part of this research is the procedures and algorithms that was utilized in obtaining the desired results so as to enhance the detection of depression. In this research, the abovementioned classifiers were used to create a stack ensemble model that was used on the dataset to compare with the other base classifiers in improving the performance of predicting depression in Northwest Nigeria.

Combining the advantages of several models, ensemble learning approaches have become a potent way to increase prediction accuracy, resilience, and equity [12], [7], [1]. An ensemble model technique can offer a more dependable trustworthy framework for depression diagnosis in Northwestern Nigeria by combining several classifiers, such as based language models and conventional machine learning algorithms. Ensemble techniques tailored to local languages and cultural expressions remain underexplored.

By merging individual base machine learning classifiers such as Random Forest (RF), Decision trees (DT), Support Vector Machines (SVM) and K-nearest Neighbors (KNN) that were not commonly used in previous studies in depression detection to classify the retrieved sample dataset in order to improve the accuracy of depression identification in people in Northwest and Nigeria as a whole through the use of stack ensemble learning techniques [7], [16].

The stack ensemble technique concatenates the outputs of all the four individual based classifiers and create an input to the meta classifier to enhance performance and improve accuracy level. Figure 3 below illustrates our methodological workflow.

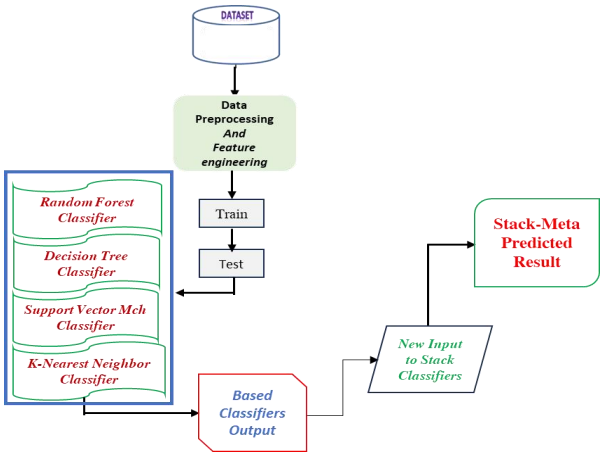

Fig. 3: Workflow Diagram for Stack Ensemble

C. Experimental Setup

The system was developed using the following hardware and software tools:

-Programming Language: Anaconda from Python.

- Libraries/Frameworks: Scikit-learn, Pandas, Matplotlib, Seaborn and NumPy.

- Development Tools: Jupyter 39 Notebook Environment.

-Operating System: Windows 11 pro version Ryzen AMD Radeon with Processor: 6300U CPU and 8 GB RAM.

V. DATASET

Practitioners working on machine learning for binary classification and regression, datasets are very important in

data analysis and machine learning. A dynamic decision-making progression for establishments and the entire nation will be significantly improved by meaningful utilization of data [25]. The vast majority of these machine learning experiments used prepackaged datasets from online repositories like Kaggle and UCI, as well as data from the United States; this provides researchers with a starting point for examining global public health challenges.

The absence of actual dataset has significantly burdened researchers on depression detection. However, incomplete data on the occurrence of depression is available for limited countries, due to lack of cumbersome dataset on the occurrence of depression in respect of Northwest Nigeria, a sample depression detection dataset with two main dialects of the ethnic group and English language was retrieved from some rural primary health care maternities of the region of studies for this research.

VI. RESULTS AND DISCUSSION

Results are vital evidence needed in every research. In this research, we splitted the dataset into training set and testing set for the four based individual classifiers such as Random Forest, Decision Tree, Support Vector Machine and K-Nearest Neighbor. We employed Jupyter notebook from Anaconda to explore the experiment which assists in determining the best classifier among the individual base classifiers and to serve as an input to the stack ensemble meta classifier. Diverse machine learning performance metrics that include classification accuracy was used to compare these classifiers; Recall, Precision, and F1-score respectively. while confusion matrix and ROC curve tables and graphs were plotted for clearer visualization of the entire results [30].

Subsequent to the training and test phase of each classifier (RF, DT, SVM, and KNN), the performances of all the four classifiers accuracy, precision, recall and F1-score results are illustrated in table 1. While figure 4 below, shows the bar chart depiction of the outcomes.

Table 1: Performance evaluation of individual based classifiers

Classifiers	Accuracy	Precision	Recall	F1-score
Random Forest	86%	93%	82%	87%
Decision Tree	81%	92%	71%	80%
Support Vector Machine	89%	95%	84%	89%
K-Nearest Neighbor	85%	88%	86%	87%

The statistical values of the four classifiers are shown in table 1 above, where Support Vector Machine outperformed all other individual base classifiers with an accuracy score of 89% with tremendous precision score of 95% followed by Random Forest with an accurate score of 86% with a precision score of 93% respectively.

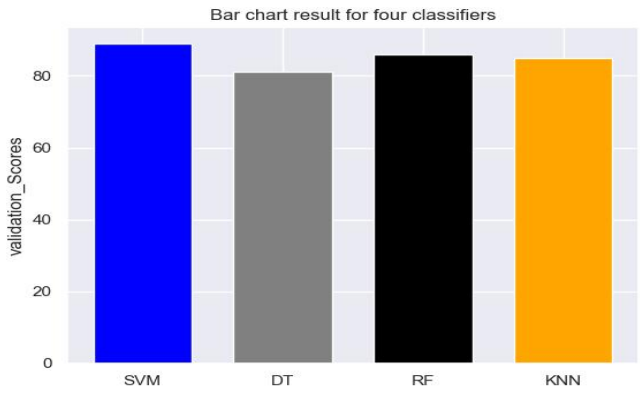

Figure 4: Bar chart Result for four Classifiers

A relative result on the Stack ensemble technique and the individual classifiers performance metrics is displayed in table 2 below. The Stack ensemble technique outperformed all other classifiers with the accuracy score of 91% followed by Support vector machine with an accuracy score of 89%, while Random Forest has an accuracy score of 86% then k-nearest neighbor followed with 85% and lastly Decision tree with 81% accuracy score. The F1-score, recall and precision result in the table reveals an outstanding score for all the classifiers.

The figure 5 below, depict the bar chart result of table 2 for clearer visualization and real evaluation of the classifiers at a glance.

Table 2: Performance evaluation of Stack Ensemble and individual based classifiers

Classifiers	Accuracy	Precision	Recall	F1-score
Random Forest	86%	93%	82%	87%
Decision Tree	81%	92%	71%	80%
Support Vector Machine	89%	95%	84%	89%
K-Nearest Neighbor	85%	88%	86%	87%
Stack Ensemble Technique	91%	95%	86%	90%

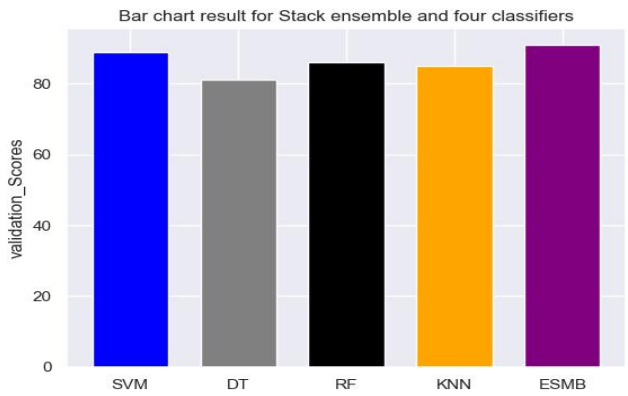

Figure 5: Bar chart Result for Stack Ensemble and Base Classifiers

The confusion matrix for stack ensemble model for detecting depression in figure 6 below, offers an extra perception in determining the pros and cons of the model. And from all perception the model performed very well.

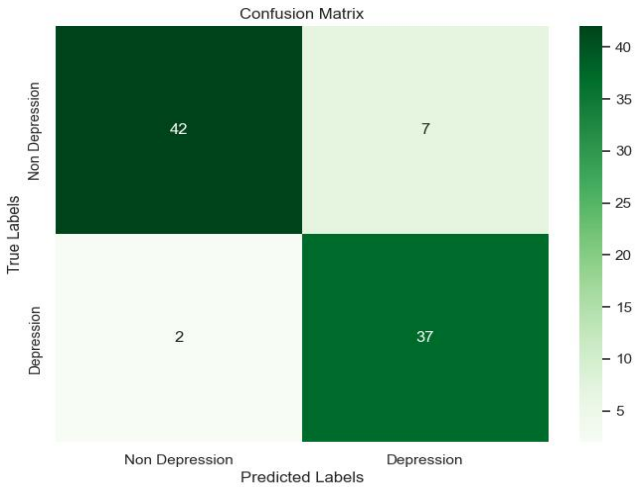

Figure 6: Confusion Matrix for Depression Detection Stack Ensemble Model

The Roc curve added by showing how correctly the stack ensemble model performed across all thresholds concurrently. Even the individual base classifiers also performed well according to the threshold, from a clearer view the stack ensemble model spot was higher than all other classifiers from the topmost left corner of the plot, which indicate how correctly the prediction was. Figure 7 below, shows the Roc curve for stack ensemble model and base classifiers for depression detection.

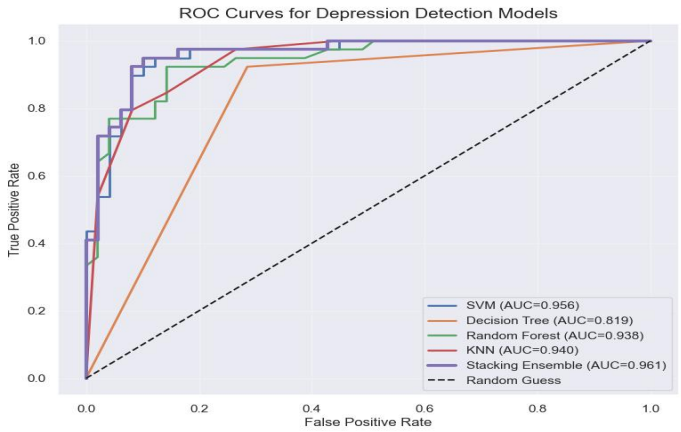

Figure.7: ROC curve plot comparing individual models with the Stack Ensemble Model.

VII. CONCLUSION

In this research, stack ensemble method was used to enhance depression detection with sample data collected from local primary healthcare centers within the various states, through the utilization of machine learning classifiers such as Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN) and Decision Tree (DT) to form a Meta-Stack Ensemble classifier. The performance of the results in this research donate to the decision that stack ensemble model is a benchmark to enhance depression detection in Northwestern Nigeria. This research is significant for several advancements which includes:

a. Recognizing and solving the traditional processes of detecting depression in northwestern Nigeria.

b. Development of the Stack Ensemble machine learning technique to enhancing depression detection Accuracy in Northwest Nigerian Adults.

c. It compares the ensemble technique with individual base classifiers to determine the most effective method.

In summary, this research captions an extensive improvement in our knowledge and response to an enhanced detection depression in Northwest Nigeria. It highlights the importance of merging trending analytical methods to health research. To efficiently enhance the detection of depression, it is authoritative to adapt these findings into practicable policy

and endlessly improving the approaches based on current datasets to inspire multifaceted collaboration.

VIII. CONCLUSION AND FUTURE WORK

Consequently, the successfulness of these initiatives will be appraised by statistical advancement and also improvement in the well-being, contentment, and prospects for the future of Northwestern Nigerian. This research lays the basis for such improvements, supporting the predominant mission of guaranteeing healthy lives and advancing everyone's comfort in accordance with international sustainable development goals.

IX. DECLARATIONS

A. Funding

This research titled: Enhancing Depression Detection Accuracy in Northwest Nigerian Adults Using Ensemble Learning Technique was funded by Tertiary Education Trust Fund (TETFund) Nigeria, (Ref ID: TETF/DR&D/CE/UNI/GUSAU/IBR/2026/VOL.1).

B. Conflict of Interest

None

C. Data Availability

The data that support these findings was retrieved privately with the concert of the Primary Health care practitioners of the selected rural community of the various region.

D. Ethics Statement

If your study involved human subjects, animals, or sensitive data: name the IRB/Ethics Committee and approval number. If not applicable, write "This study did not involve human or animal subjects."

E. Author Contributions

Data preprocessing: Shuaibu Samaila and Mohammed Ali Kawo.
Formal analysis: Mohammed Ali Kawo
Methodology: Mohammed Ali Kawo and Shuaibu Samaila.
Original draft: Mohammed Ali Kawo
Review & editing: Shuaibu Samaila and Mohammed Ali Kawo.

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XI. REFERENCES

[1] Ahmmed, M. M., Noman, A. A., Afif, M. M., Kabir, K. M. T., Rahman, M. M., & Mufti, M. (2025). A model-mediated stacked ensemble approach for depression prediction among professionals. arXiv Preprint. https://arxiv.org/abs/2506.14459

[2] Alvarado, R., He, L., & Baldwin, T. (2020). Improving mental health classification via ensemble deep learning models. Proceedings of the 12th Language Resources and Evaluation Conference (LREC), 4358–4366.

[3] Bader, M., Kumar, R., Singh, A., & Lee, C. (2024). Detecting depression severity using weighted random forest. Scientific Reports, 14(1), 67251. https://doi.org/10.1038/s41598- 024-67251-y

[4] Bala, A., & Ibrahim, M. (2022). Natural language processing for Hausa and Fulfulde: Challenges and opportunities. International Journal of African Language Technology, 5(2), 45–56.

[5] Chukwu, E., Onwuchekwa, J., & Nweke, H. (2020). Text mining applications in Nigerian healthcare: A review of challenges and opportunities. African Journal of Health Informatics, 14(1), 22–30.

[6] Cui, S., Ajayi, B., Kim, E., & Egonu, R. (2022). A Systematic Review and Meta-Analysis of Depression Prevalence amongst Nigerian Students Pursuing Higher Education. 589–598. https://doi.org/10.4236/jbbs.2022.1211035

[7] Feng, W., Gou, J., Fan, Z., & Chen, X. (2023). An ensemble machine learning approach for classification tasks using feature generation. Connection Science, 35(1). https://doi.org/10.1080/09540091.2023.2231168

[8] Hussain, N., Shaukat, Z., & Khan, R. (2025). Multi-level depression severity detection with deep and classical machine learning models. Machine Learning and Knowledge Extraction, 6(7), 157. https://doi.org/10.3390/make6070157

[9] Imans, D., Nguyen, T., Abed, A., & Liu, Y. (2024). Explainable multi-layer dynamic ensemble framework for depression detection. Frontiers in Psychiatry, 15, 11545061. https://doi.org/10.3389/fpsyt.2024.11545061

[10] Isara, A. R., Nwokoye, O. I., & Odaman, A. O. (2022). Prevalence and risk factors of depression among undergraduate medical students in a Nigerian university. 56(4), 303–310.

[11] Iyortsuun, N. K., Kim, S. H., Jhon, M., Yang, H. J., & Pant, S. (2023). A review of machine learning and deep learning approaches on mental health diagnosis. Healthcare, 11(2), 452. https://doi.org/10.3390/healthcare11030452

[12] Jawale, S. (2019). Sentiment Analysis using Ensemble Learning Doctoral dissertation, California State University, Northridge. https://scholar.google.com/scholar?q=Jawale,+S.+P.

[13] Kanani, R., Fiaidhi, J., & Patel, V. (2022). Depression Sentiment Analysis Based on Social Content like Twitter. https://doi.org/10.36227/techrxiv.21694676.v1

[14] Nadeem, A., Fatima, I., Jamal, M., & Irtaza, A. (2022). Depression detection based on hybrid deep learning. Computational and Mathematical Methods in Medicine, 2022, Article 9782829. https://doi.org/10.1155/2022/9782829

[15] Nickson, D., Meyer, C., Walasek, L., & Toro, C. (2023). Prediction and diagnosis of depression using machine learning with electronic health records data: A systematic review. BMC Medical Informatics and Decision Making, 23(1), 271. https://doi.org/10.1186/s12911-023-02341-x

[16] Obagbuwa, I. C., Adebiyi, M. O., & Omisore, M. O. (2023). Supervised machine learning models for depression and sentiment analysis in social media data. Frontiers in Artificial Intelligence, 6, 1230649. https://doi.org/10.3389/frai.2023.1230649

[17] Oloruntoba, S., Adebayo, O., & Adepoju, A. (2021). Sentiment analysis of Nigerian social media text: Addressing Hausa-English code-switching. Journal of Computing and Intelligent Systems, 9(3), 55–66.

[18] Orabi, A. H., Buddhitha, P., Husseini, A., & Inkpen, D. (2018). Deep learning for depression detection of Twitter users. Proceedings of the Fifth Workshop on Computational Linguistics and Clinical Psychology, 88–97.

[19] Park, M., Mcdonald, D. W., & Cha, M. (2021). Perception Differences between the Depressed and Non-Depressed Users in Twitter. In Proceedings of the International AAAI Conference on Web and Social Media, 476–485. www.aaai.org

[20] Saha, B., Nguyen, T., Phung, D., & Venkatesh, S. (2016). A Framework for Classifying Online Mental Health-Related Communities with an Interest in Depression. IEEE Journal of Biomedical and Health Informatics, 20(4), 1008–1015. https://doi.org/10.1109/JBHI.2016.2543741

[21] Saha, D. K., Hossain, T., Safran, M., Alfarhood, S., Mridha, M. F., & Che, D. (2024). Ensemble of hybrid model-based technique for early detecting of depression based on SVM and neural networks. Scientific Reports, 14(1), 25470. https://doi.org/10.1038/s41598-024-77193-0

[22] Selvaraj, A. (2024). Enhancing depression detection: A stacked ensemble model (DESGM). Applied Sciences, 14(16), 7366. https://doi.org/10.3390/app14167366

[23] Tadesse, M. M., Lin, H., Xu, B., & Yang, L. (2019). Detection of depression-related posts in Reddit social media forum. IEEE Transactions on Computational Social Systems, 6(5), 976–988. https://doi.org/10.1109/TCSS.2019.2918282

[24]Temitayo, I., Tabiri, I., Modupe, O., Olusola, E., Romain, A., Koomson, A., Torbi, J., Ehindero, S., Susan, F., Yusha, Y., Keji-taofik, S. T., Peter, R., & Amatey, T. (2022). IBRO Neuroscience Reports Depression in Sub-Saharan Africa. IBRO Neuroscience Reports, 12(April 2021), 309–322. https://doi.org/10.1016/j.ibneur.2022.03.005

[25] Theobald, O. (2024). Machine learning for absolute beginners: A plain English introduction (3rd ed.). Sanage Publishing House LLP. ISBN 978-9362056863

[26] Vandana, Marriwala, N., & Chaudhary, D. (2023). A Hybrid Model for Depression Detection Using Deep Learning. https://doi.org/10.1016/j.measen.2022.100587

[27] Wang, Z., Chen, L., Wang, L., & Diao, G. (2020). Recognition of Audio Depression Based on Convolutional Neural Network and Generative Antagonism Network Model. IEEE Access, https://doi.org/10.1109/ACCESS.2020.2998532 8

[28] World Health Organization. (2023). Depression: Key facts. https://www.who.int/news- room/fact-sheets/detail/depression

[29] Zhang, Y., Chen, F., & Xu, J. (2021). Ensemble learning for imbalanced data classification: A comprehensive review. Knowledge-Based Systems, 233, 107529. https://doi.org/10.1016/j.knosys.2021.107529

[30] Zhou, F., Fan, H., Liu, Y., Zhang, H., & Ji, R. (2023). Hybrid Model of Machine Learning Method and Empirical Method for Rate of Penetration Prediction Based on Data Similarity. Applied Sciences (Switzerland), 13(10). https://doi.org/10.3390/app13105870